Opportunities for Biotechnology In Canadian Specialty Crops

Prepared

By

Agri Studies Inc.

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Foreword

This report was prepared by Dr. Thomas F. Funk of Agri Studies Inc. The project was carried out under contract with Industry, Science, Technology Canada. Appreciation is extended to Dr. Terry Walker of Industry, Science, Technology Canada for his assistance in organizing the work and reviewing the final report.

Executive Summary

A project was begun in January of 1990 to investigate potential opportunities for biotechnology in specialty field crops in Canada. Four crop areas were identified for detailed evaluation: vegetable brassicas, mustard seed, soybeans, and winter wheat. The objectives of the project were to:

1. Assemble data on acreage, production, and value by region for the past five years for each of the four crops.

2. Determine the current uses of each crop.

3. Determine the major problems and opportunities in the production, marketing, and use of each crop.

4. Determine the value of improvements for each crop.

5. Determine the availability of Canadian expertise to develop and market products with improved characteristics.

The project was carried out in two phases. In the first phase, objectives one through four were completed for each of the four crop areas. These results were reviewed with the client and a decision made to complete objective five only for winter wheat. This was done because it was felt that the economic benefits of pursuing biotechnology in the other three crop areas were too small to justify further investigation.

Data for the research came from two major sources. The first source was published statistical information generated by Statistics Canada, Provincial Departments of Agriculture, the Canadian Wheat Board, and the United States Department of Agriculture. The second source was a series of in-depth interviews conducted with a variety of industry, government, and university people across Canada and a few in the United States.

The major findings and conclusions of the study are discussed below by major crop area.

Vegetable Brassicas

1. With the exception of rutabagas, Canada does not have a competitive advantage in the production of vegetable brassicas. As a result, production of these crops in Canada is extremely small.

2. Although Canada has a competitive advantage in the production of rutabaga, there is declining demand both within Canada and in export markets for this product.

3. There is no vegetable brassica seed industry in Canada which could benefit from biotechnology research developments.

4. There is no conventional vegetable brassica breeding effort in Canada which would be required to move biotechnological advances into actual varieties

5. All survey respondents indicated that conventional breeding is the most important research activity at the present time. None of the respondents felt that Canada could justify biotechnology research expenditures in this area.

6. It appears that there is little potential for biotechnology research in vegetable brassicas in Canada within the foreseeable future.

Mustard Seed

1. Even though Canada is the dominant producer of mustard seed for export purposes in the world, the economic value of the crop to Canadian farmers is quite low.

2. There are a number of problems with mustard seed that could be tackled using biotechnology. Some of the more significant of these problems are disease resistance, yield improvements, drought tolerance, triazine resistance, and varying the oil composition of the finished product. The gross value of improvements in these areas at the farm level is in the vicinity of $5 to $6 million. A smaller level of domestic economic return could be anticipated for seed producers. In addition, the economic return to seed producers could be increased by exporting seed to other countries. This, however, would be limited by the small world production of the crop. Unless seed improvements come in the form of hybrid seed, the value to the seed industry would be seriously limited because farmers could simply save seed from year to year instead of purchasing new seed every year.

3. At the present time, there are no seed companies involved in developing and marketing proprietary mustard seed varieties. All seed used in the industry is of public origin, most of which is simply "bin run" seed. As a consequence, any biotechnology research and development in the short run would have to be carried out by government agencies. Some of this type of work is currently underway at the Agricultural Canada Research Station in Saskatoon.

4. Most respondents to our survey indicated that improving farmers' management capabilities in producing mustard seed was at least as important as research on the crop itself.

5. Although there are areas of needed improvement in mustard seed varieties, the economic value of the crop is very low. Although some spin off research from the major effort currently underway in Canola could be applied to mustard seed, the importance of the crop to Canadian agriculture cannot justify a major biotechnology research effort.

Soybeans

1. A key objective with respect to soybeans was to investigate the possible role of biotechnology related to developing improved cold tolerance. Although this has been a problem in the past, apparently it is not a serious problem at the present time.

2. The major problem identified in the survey of industry experts relates to oil composition. This problem is being addressed by many researchers in major soybean producing countries. Canada probably does not have a competitive advantage in this area. Moreover, it probably is not in Canada's best long run interest to improve the oil composition of a crop which is a major competitor to Canola, a truly Canadian crop which increasingly is being seen as a superior oilseed. At the present time, there is nearly 4 million hectares of Canola grown in Canada. Millions of dollars of research funding have been allocated to Canola over the last several years to improve its oil quality and agronomic characteristics. These research expenditures are just now starting to pay off with the development of new hybrid Canola varieties that can be grown in both Canada and the United States. There is no doubt that the productivity of new Canadian research dollars would be higher in Canola than in soybeans.

3. Relative to many other crops, there does not appear to be a large number of significant problems associated with soybean production in Canada. Most of the important disease and insect problems are being controlled through resistant varieties.

4. Soybeans appear to be a difficult crop for applying biotechnology techniques.

5. The soybean seed industry in Canada is small and not well-developed at this time. There does not appear to be substantial foreign opportunities for Canadian soybean seed.

6. Based on this assessment of the potential for biotechnology research in soybeans, our conclusion is that this would be a very low priority area.

Winter Wheat

1. The production of winter wheat in the Prairies has a lot of potential. Although currently there is less than 250,000 hectares of winter wheat in Western Canada, there is a potential for 2,000,000 hectares.

2. The key limiting factor to the growth of winter wheat in Western Canada is winter hardiness. There are additional problems with respect to diseases and protein content, but these are minor in comparison with hardiness.

3. Winter wheat offers a large number of advantages to growers over spring wheat. When considered together, these advantages can contribute up to $55 per hectare in incremental net returns to growers. At current prices, the total value of these improvements approaches $100,000,000 annually. As the price of wheat varies, the value of the improvements will also vary, but will always remain substantial and positive.

4. The seed industry can also benefit from improvements in winter wheat. The annual benefit to the seed industry is in the neighborhood of $3 million.

5. The value of improvements in winter wheat appear to be of sufficient size to justify devoting additional research resources to this area.

6. There are four active Canadian research programs in winter wheat in Western Canada. Of these, the program at the University of Saskatchewan is the largest and most highly developed. Allocating research funds to this program to help in the development of interspecific crops, and locating genes that regulate winter hardiness, would appear to be a high priority activity.

Recommendations

Based on the analysis completed in this project, the following recommendation can be stated. Serious consideration should be given to increasing the funding support of biotechnology in the development of hardiness in winter wheat. This increased funding should be directed mainly to the current winter wheat development program at the University of Saskatchewan. Some increased funding should be considered for the development of basic tools such as anther culture at the University of Manitoba.

Increased funding of biotechnology is not warranted for vegetable brassicas, soybeans, or mustard seed.

Vegetable Brassica

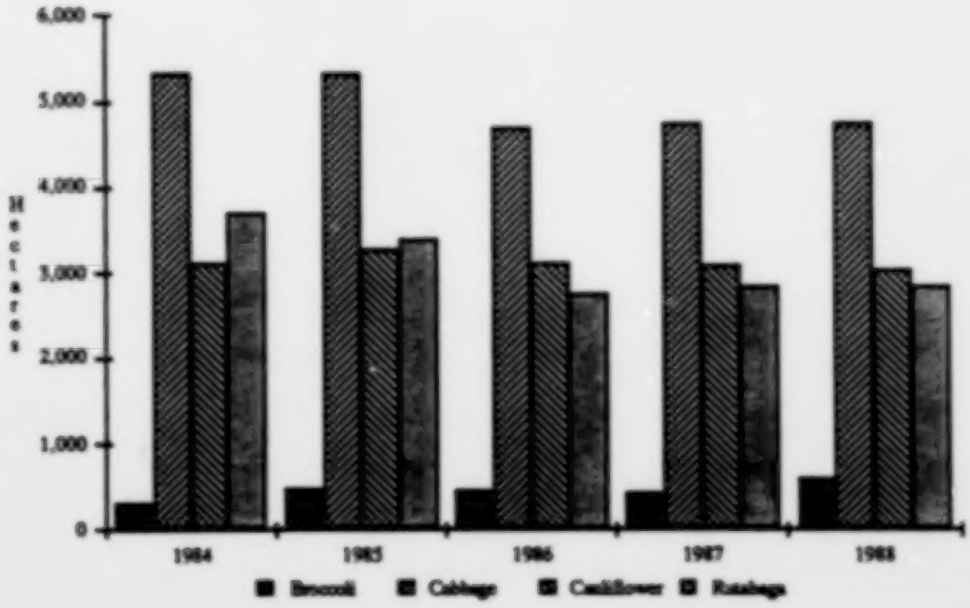
The first specialty crop to be analyzed in this project is vegetable brassicas. Although there are a number of vegetables that fall into this category, the analysis in this report has been confined to the four major vegetable brassicas: broccoli, cabbage, cauliflower, and rutabaga.

Canadian Production

Total production of the four major vegetable brassicas in Canada is limited to approximately 12,000 hectares. Of this total, cabbage is the largest crop at approximately 5,000 hectares, followed by cauliflower and rutabaga at 3,100 hectares each, and broccoli at 500 hectares. Over the past five years, the area of land devoted to cauliflower has remained more or less stable, while the area devoted to cabbage and rutabaga has declined. The only vegetable brassica to show an increase over the past five years is broccoli which has exhibited an area increase of over 40 percent between 1984 and 1988 (Exhibit 1).

Exhibit 1

Canadian Production of Vegetable Brassicas



In terms of farm value, cabbage is the largest crop with a farm value of over $30 million. This is followed by cauliflower at $23 million, rutabaga at $15 million, and broccoli at only $2 million (Exhibit 2).

Exhibit 2

Total Value of Vegetable Brassicas Produced in Canada

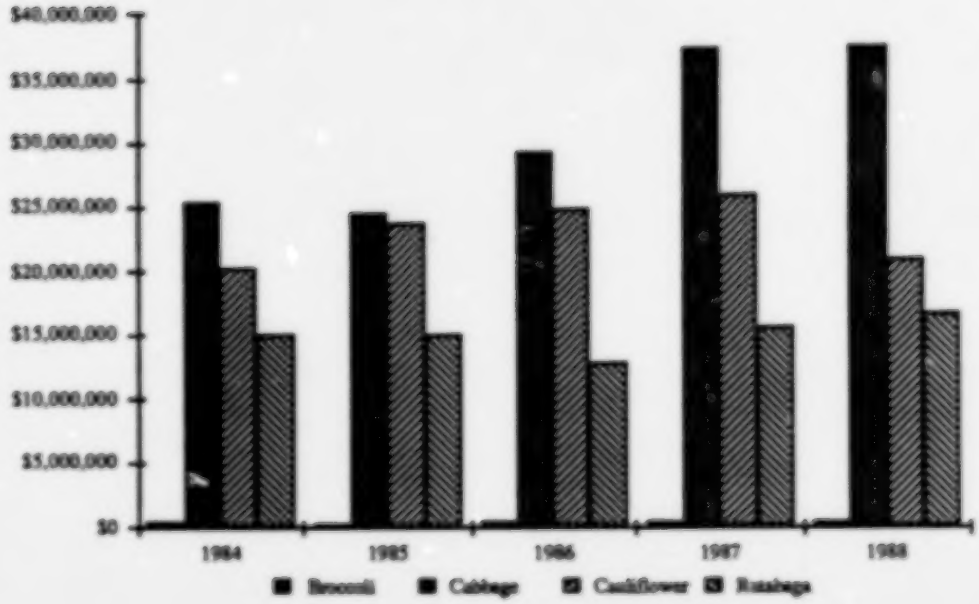


Exhibit 3 presents a complete statistical summary of vegetable brassica production in Canada.

Exhibit 3

Vegetable Brassica Production and Value Data

Broccoli

	Production (Tonnes)	Area (Hectares)	Yield (Tonnes/Ha)	Farm Price ($/Tonne)	Value ($)
1984	2,692	342	7.87	$550.14	$1,481,000
1985	3,720	482	7.71	$462.90	$1,722,000
1986	3,817	460	8.29	$441.70	$1,686,000
1987	2,958	425	6.96	$754.60	$2,232,000
1988	4,797	609	8.29	$915.20	$4,390,000
Average	**3,597**	**464**	**7.82**	**$624.91**	**$2,302,200**

Cabbage

	Production (Tonnes)	Area (Hectares)	Yield (Tonnes/Ha)	Farm Price ($/Tonne)	Value ($)
1984	123,132	5,336	23.08	$206.87	$25,472,000
1985	156,200	5,338	29.26	$156.38	$24,427,000
1986	140,131	4,700	29.81	$208.88	$29,270,000
1987	148,863	4,751	33.43	$250.80	$37,334,000
1988	138,292	4,761	29.04	$272.80	$37,276,000
Average	**141,324**	**4,977**	**28.92**	**$219.15**	**$30,755,800**

Cauliflower

	Production (Tonnes)	Area (Hectares)	Yield (Tonnes/Ha)	Farm Price ($/Tonne)	Value ($)
1984	50,960	3,122	16.32	$399.53	$20,360,000
1985	52,923	3,288	16.10	$449.79	$23,804,000
1986	57,342	3,131	18.31	$432.98	$24,828,000
1987	55,978	3,080	18.17	$462.00	$25,862,000
1988	36,190	3,059	11.83	$578.60	$20,940,000
Average	**50,679**	**3,136**	**16.15**	**$464.58**	**$23,158,800**

Rutabaga

	Production (Tonnes)	Area (Hectares)	Yield (Tonnes/Ha)	Farm Price ($/Tonne)	Value ($)
1984	112,378	3,684	30.50	$135.24	$15,198,000
1985	92,584	3,401	27.22	$163.16	$15,106,000
1986	93,655	2,768	33.83	$137.10	$12,840,000
1987	96,051	2,855	33.64	$163.10	$15,666,000
1988	86,562	2,832	34.03	$182.60	$16,655,000
Average	**96,246**	**3,108**	**31.84**	**$156.24**	**$15,093,000**

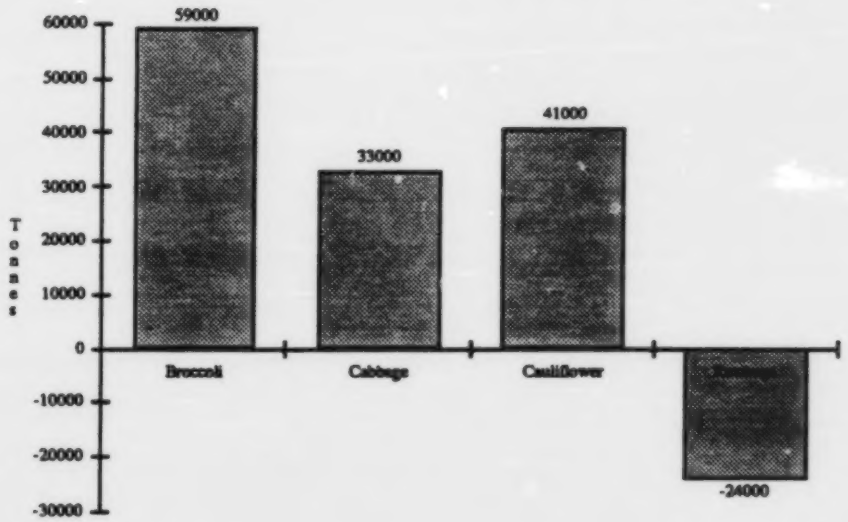
Imports and Exports of Vegetable Brassicas

At the present time, Canada is a net importer of broccoli, cabbage, and cauliflower. In 1988, over 90 percent of all broccoli consumed by Canadians was imported, mainly from the United States. For cabbage and cauliflower, the comparable percentages imported were 20 percent and 50 percent respectively. The reason for the very high percentage of broccoli imported into Canada, and the moderately high percentage of cauliflower, is related directly to storage possibilities. Whereas cabbage can be stored for extended periods of time, cauliflower, and particularly broccoli, can withstand only relatively short storage periods. As a result, the bulk of Canadian production of these two vegetables is for immediate consumption. At the present time, Canadian production of broccoli is less that 1 percent that of the United States, while Canadian production of cauliflower and cabbage is closer to 10 percent that of the United States.

In the case of rutabagas, Canada is a net exporter. In 1988, over 25 percent of the rutabaga crop in Canada was exported to the United States. The United States does not produce rutabagas; they do grow a substantial amount of white turnips, which are a close substitute (Exhibit 4).

Exhibit 4

Imports and Exports of Vegetable Brassicas



Problems (Broccoli, Cabbage, and Cauliflower)

Respondents to our survey identified several problems associated with the production and marketing of broccoli, cabbage, and cauliflower in Canada. The key problems are:

1. Vegetable brassicas are essentially cold weather crops. Although this would seem to make the production of these crops very viable in Canada, this is not the case. For the most part, the fertile regions of Canada are relatively cool in the spring and fall, but can be extremely hot in the summer. The extreme summer temperatures cause vegetable brassica plants to bolt and develop unfavourable morphological characteristics. This, in turn, substantially reduces their market value.

2. The production of vegetable brassicas is very labour intensive. Virtually all harvesting of these crops must be done by hand. This gives California, and other similar regions of the United States, a distinct advantage because of the relatively larger supply of less expensive, migrant labour available in these regions.

3. Both broccoli and cauliflower have short storage periods. This means that it is not possible for Canadian producers to maintain inventories of Canadian stocks for more than a few weeks. As a result, Canadian production is able to displace imports from the United States only during the peak production season in Canada. At all other times, supplies must come from outside Canada. This is not a major problem for cabbage. The fact that all Canadian production comes on the market in a very short period of time means that grower prices are severely depressed during this period of time.

4. Vegetable brassicas require relatively high levels of boron in the soil to achieve reasonable yields. Areas in Canada with adequate boron for brassica production are restricted. This means that brassica production must be confined to these areas, or growers must invest in micronutrients to bring boron levels up to acceptable levels.

5. For optimum production, brassica varieties are restricted to relatively small regions due to climatic factors and day length characteristics. This means that the size of the market for a new variety in Canada can be very small.

6. In order to insure ample time for growth and development, most of the broccoli, cauliflower, and cabbage grown in Canada must be started in a greenhouse and then transplanted to fields. This dramatically increases production costs in Canada.

7. There are some disease problems in vegetable brassicas which affect yields. These include: Black Rot, Head Spotting, and Fuserium Yellow. In general, these diseases are not considered major problems because they only affect small acreages and do not lead to substantial yield reductions.

Problems (Rutabaga)

Respondents to the survey also listed several problems associated with the production and marketing of rutabagas.

1. Consumer demand for the product is declining rapidly. In general, rutabagas are considered an inferior good purchased mainly by low income households. In some areas the major use for rutabagas is in animal feed. The production statistics cited earlier reinforce this point of view. Total Canadian production of rutabaga has declined by over 25 percent in the past five years. To a large degree, this decline in demand is due to ineffective marketing in the United States by the rutabaga industry. Although this trend could be reversed, it is very unlikely that this will occur in the foreseeable future.

2. In the last few years there has been a significant increase in the seriousness of viral diseases in rutabagas. A disease similar to the cauliflower mosaic has infested a very large proportion of Canadian rutabaga acres. This disease is carried by insects associated with canola, and has increased in rutabaga as more and more rutabaga growers have diversified into canola production. Current estimates place the percentage infestation at nearly 90 percent.

Canadian Vegetable Brassica Seed Industry

At the present time, there is not a vegetable brassica seed industry in Canada. This is due to two factors: the extremely small size of the vegetable brassica industry in this country and climatic factors. The first of the two reasons already has been discussed, so only the second will be dealt with at this point.

Vegetable brassica seed production requires very specific climatic conditions. Because vegetable brassicas are biennial plants, they need to overwinter in temperatures of approximately 4 to 5 degrees centigrade for 6 weeks. There are essentially very few areas of Canada that would permit this to occur. In addition, proper flowering for seed production requires cool temperatures during the summer. As noted earlier, the temperature extremes in Canada are such that bolting tends to occur with some regularity. Because of the very specific climatic conditions required for vegetable brassica seed production, only a few areas of the world have been identified as ideal. These areas are in California, Arizona, and Texas. There is very little likelihood of a Canadian vegetable brassica seed industry ever developing.

In addition to the lack of a vegetable brassica seed industry in Canada, there is no developed conventional breeding programs sponsored by universities or governments.

The value of vegetable brassica seed used in Canada is relatively small. At a seeding rate of 1 kg/ha, and a cost of $300 per kg, the total annual value of vegetable brassica seed used in Canada is approximately $3.5 million.

Research Opportunities

A few research opportunities have been uncovered in this study. In general, these relate to using conventional research supported by existing biotechnology practices such as tissue culture. It is interesting to note that virtually no research is being carried out in Canada at the present time on vegetable brassicas.

The major opportunities identified are:

1. Improve regional adaptability of existing vegetable brassica cultivars.
2. Develop vegetable brassica cultivars that are adaptable to mechanical harvesting techniques.
3. Develop broccoli which can be produced in Canada and come on the market earlier and later to compete with imports from United States.
4. Improve the storage characteristics of broccoli and cauliflower.

Conclusions

It appears that there is little potential for biotechnology research in Canada within the foreseeable future. The key reasons for this are:

1. With the exception of rutabagas, Canada does not have a competitive advantage in the production of vegetable brassicas. As a result, production of these crops in Canada is extremely small.

2. Although Canada has a competitive advantage in the production of rutabaga, there is declining demand both within Canada and in export markets for this product.

3. There is no vegetable brassica seed industry in Canada which could benefit from biotechnology research developments.

4. There is no conventional vegetable brassica breeding effort in Canada which would be required to move biotechnological advances into actual varieties

5. All respondents to our survey indicated that conventional breeding is the most important research activity at the present time. None of the respondents felt that Canada could justify biotechnology research expenditures in this area.

Recommendations

It is quite clear from the analysis completed on vegetable brassicas that this crop area be given a very low priority rating for future biotechnology funding.

Mustard Seed

The second special crop to be analyzed in this report is mustard seed. The specific assignment is to analyze the economic benefits of developing new mustard seed varieties with improved agronomic characteristics.

Canadian Production

Mustard seed is a crop in which Canadian farmers have a distinct competitive advantage over most other areas of the world. This is because the crop has day length and climatic requirements which are very consistent with conditions in the Prairie provinces. As a consequence, Canada is the world's leading producer of this crop for export purposes. As shown in Exhibit 1, the land mass devoted to mustard seed production over the past five years has varied from slightly more than 100,000 hectares to nearly 185,000 hectares. The five year average is 142,160 hectares as shown in Exhibit 2. Saskatchewan produces 76% of Canadian mustard seed, followed by Alberta a 17%, and Manitoba at 7%. All mustard seed in Canada is produced under contract to a limited number of private and cooperative organizations.

Exhibit 1

Canadian Production of Mustard Seed

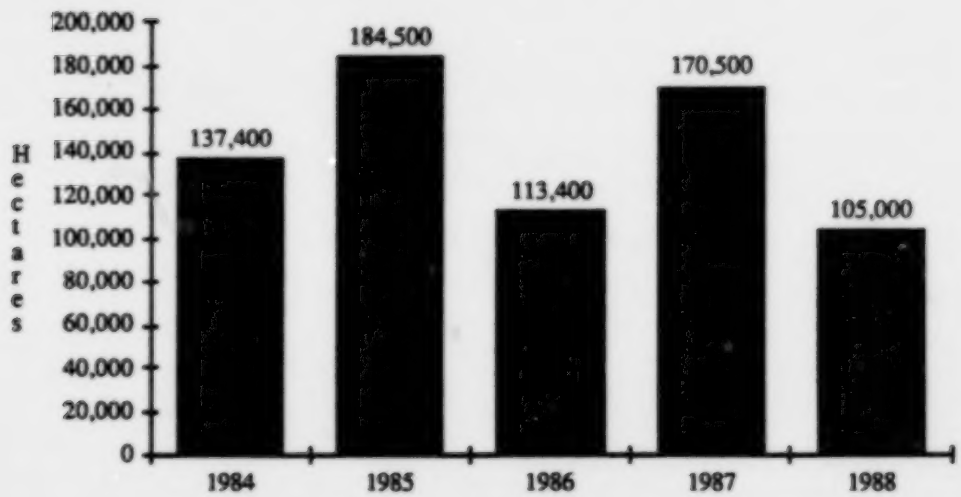


Exhibit 2

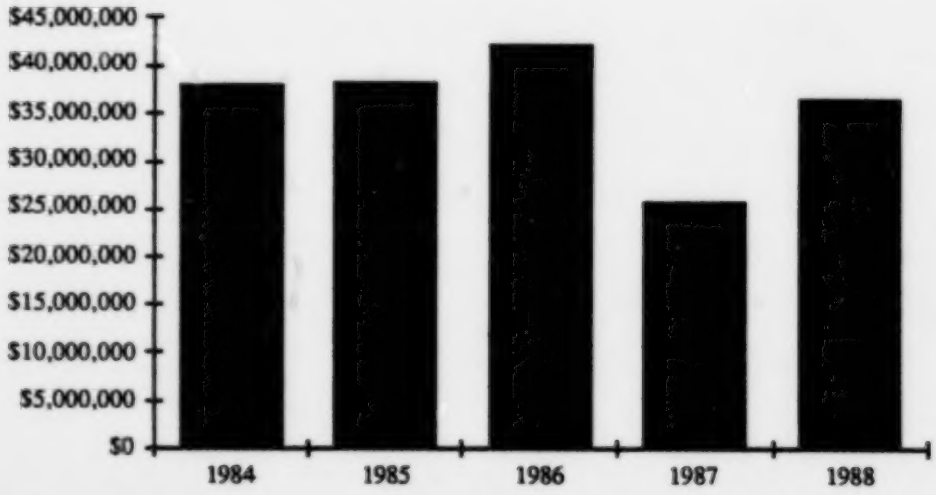
Mustard Seed Production and Value Data

	Production (Tonnes)	Area (Hectares)	Yield (Tonnes/Ha)	Farm Price ($/Tonne)	Value ($)
1984	112,400	137,400	0.82	$339.00	$38,103,600
1985	125,300	184,500	0.68	$307.00	$38,467,100
1986	226,800	113,400	2.00	$230.00	$52,164,000
1987	132,400	170,500	0.78	$195.00	$25,818,000
1988	122,900	105,000	1.17	$297.00	$36,501,300
Average	143,960	142,160	1.09	$273.60	$38,210,800

When expressed in terms of farm value, mustard seed has ranged from a high of over $50 million in 1986 to a low of just over $25 million in 1987 (Exhibit 3). The average value over the past five years has been $38,210,000.

Exhibit 3

Total Value of Mustard Seed Produced in Canada



There are three main types of mustard seed produced in Western Canada: yellow mustard, brown mustard, and oriental mustard. Although exact statistical information is not available on production of each type, industry sources have given the following estimates:

Yellow	50%	71,500 tonnes
Brown	35%	50,400 tonnes
Oriental	15%	21,600 tonnes

As might be expected, most of the yellow type is used in the production of "hot dog" mustard. In addition, substantial quantities of yellow mustard are ground into flour for use in mayonnaise. Brown mustard is used mainly in wet-pack table mustards in Europe, while oriental mustard is used in manufacturing a large number of products in Japan. Some oriental mustard is also used in mayonnaise. The demand for yellow mustard is very constant and not expected to increase in the future. The demand for both brown and oriental mustard has shown some growth in the recent past and is expected to continue to show modest growth in the future.

Global Production and Use

It is virtually impossible to obtain information on the production of mustard seed in other countries. This is because most countries group mustard seed and rapeseed together and report them as a single category. Only Canada reports mustard seed production as a separate entity. Despite this problem, industry experts were able to estimate that Canada produces over half of total global production. This means that world production is somewhere in the vicinity of 300,000 tonnes per year. Most industry experts felt that Czechoslovakia was the second largest producer of mustard seed in the world.

Canada is the only country in the world to export sizeable volumes of mustard seed. Canadian exports of mustard seed average approximately 80% of annual production. By far, the largest export customer is the United States, followed by the Netherlands, Japan, and West Germany. Over the last few years, Bangladesh has become a major importer of Canadian mustard seed. Unlike other countries, Bangladesh uses the product as an edible oil. The United States imports yellow mustard, Europe imports brown mustard, and Japan imports oriental mustard.

Seed Industry

All mustard seed currently produced in Canada is grown from public varieties. As a result, there are no seed firms in the country that have developed proprietary varieties. Because the crop is grown under contract with various grain companies, the grain companies themselves control the distribution of seed to growers. There is an active mustard seed breeding program in operation at the Agriculture Canada research station in Saskatoon. This is the only mustard seed research effort being undertaken in the country at the present time.

On average, it takes approximately 10 kg of seed to plant one hectare of mustard seed. Seed is valued at about $0.80 per kg. This means that seed costs to a farmer are in the vicinity of $8 per hectare. Over the entire production area of approximately 140,000 hectares, an estimate of the annual value of seed would be $1.1 million. Of this total, probably more than 90% is "bin run" seed saved from previous crops and planted in subsequent years. As a result, the value of sales of certified seed to growers in any year most likely is in the vicinity of $100,000.

Problems in the Production and Marketing of Mustard Seed

Respondents to our survey identified several problems associated with the production and marketing of mustard seed. The following discussion is divided into three main categories: yellow mustard, brown and oriental mustard, and general.

Yellow (Sinapis Alba)

1. Yellow mustard has developed from a very narrow genetic base of material originally found in Northern Africa. As a result, there are few natural alternatives for breeding purposes. To date, mustard has been difficult to cross with other species.

2. Yellow mustard has experienced large yield variations in the past. For the most part these variations can be attributed to lack of growing experience and expertise on the part of current producers. A major problem seems to be related to seedbed preparation. Poor seedbed preparation is probably costing growers 10% to 15% in yield reductions.

3. Harvesting is another agronomic problem associated with mustard. The crop doesn't always ripen uniformly requiring swathing in many instances. This leads to a loss of pods. When the product is harvested without swathing, there is inconsistent seed moisture and quality resulting in a lower grade and, therefore, a lower price for the product. The magnitude of this problem is estimated to be 5% of the value of the crop.

4. There is a need in yellow mustards for more uniformity in seed size, and larger seed size. Respondents estimated that this could improve the price to growers by as much as $40 per tonne.

5. Although some respondents indicated that increased yield in yellow mustard would be an advantage, others commented that this would simply serve to reduce the number of acres produced since the demand for yellow mustard seed is very stable and not expected to grow much in the future.

Brown and Oriental (Brassica Juncea)

1. Although not stated specifically as a problem, a few respondents indicated that it would be nice to be able to control the level of glucosinilates in brown mustard

(volatile oil). This would permit the development of varieties with different taste characteristics, and thus give Canadian producers a unique advantage in international markets. Respondents were unable to attach a quantitative estimate to the value of this characteristic.

2. There is a problem with white rust in brown mustards. Current breeding programs are attempting to develop strains that are resistant to this disease. Respondents estimated the magnitude of this problem to be a 10% yield penalty on all brown mustard.

3. There is a need for varieties that are resistant to shattering at harvest. This results in a lower grade when the producer attempts to sell the product. At the present time, approximately 70% of the crop is Number 1 grade and 30% Number 2 grade. Number 2 has a market value about 15% below Number 1. Varieties resistant to shattering could increase the percentage of the crop graded Number 1. This is not a problem with yellow mustard seed.

4. A problem with brown mustard is the bacteria Neumatospora caused by infestations of cinch bugs and dry weather. This causes problems in storing the mustard seed, and requires fumigation for control. Although not a problem at the grower level, it becomes quite significant to the major mustard packers such as French's. One respondent estimated that this problem occurred once every four years and affected up to 25% of all purchases. The cost to fumigate was estimated to be be about $0.25 per kg.

5. There is a need for new varieties which produce less green seed. Current varieties suffer from this problem which affects the colour of the finished product, hence its market value.

6. Brown and oriental mustard seed can suffer from a problem called staghead fungus.

7. It would be desirable to be able to lower the fixed oil content of brown and oriental mustard. This would make milling easier and perhaps improve price as much as $30 per tonne. One respondent indicated that it could lower milling costs by 5%.

General

1. There is a potential benefit that may be derived from an increase in the mucilage content of the seed coat. This is a glue-like substance which has benefits to food processors in enhancing flavour and acting as an emulsifying agent.

2. There was mixed opinions among the respondents with respect to the impact of wild mustard. Some respondents felt that this was not a serious problem because farmers could deal with it through proper rotations, while others felt it could be a significant problem. One respondent indicated that 10% to 15% of the total crop was infested with 1% wild mustard. At this level, the loss is approximately 20% to 30% of the total value of the crop that is affected. This problem could be solved by developing triazine resistant varieties.

3. All types of mustard seed could benefit from improved drought tolerance. The crop seems to do best in the southern prairies where drought is a significant possibility. In some years drought can result in a 50% decrease in yields and a 10% to 15% decrease in price due to lower grades. Handlers of mustard seed find this a serious problem because occasionally they are unable to meet delivery contracts in export markets. Having a more assured supply would be a decided advantage.

4. Higher yields for all types of mustard was cited by most respondents. It was generally felt that improved varieties could be developed which would be capable of generating yields at least 5% higher than at the present time. This was felt to be especially important for brown and oriental mustard seed because the market for these products is expanding.

Economic Impact of Solving Current Problems

Wherever possible, respondents were asked to estimate the economic impact associated with the problems they identified. Exhibit 4 is designed to measure the total annual benefit associated with each problem identified in the previous section. Given the nature of the estimates, the benefits in Exhibit 4 are probably maximum levels.

Exhibit 4

Economic Impacts of Solving Mustard Seed Problems

Problem	Estimate of Effect	Economic Value
Yellow		
Poor seedbed preparation	10% to 15% yield reduction on all yellow mustard seed	$2 million
Harvesting	5% of total value of yellow mustard seed	$1 million
More uniform size	$40 per tonne price advantage for yellow mustard seed	$3 million
Brown		
White rust	10% yield penalty on brown	$1 million
Resistance to shattering	Upgrade 30% of crop to Number 1 with 15% price advantage	$1 million
Neumatospora	One in four years, 25% of crop, $250 per tonne to control	$1 million
Lower fixed oil content	Improve price by $30 per tonne	$2 million

General

Wild mustard	10% to 15% of total crop experiences value loss of 20%	$1 million
Drought tolerance	50% yield decrease and 10% value decrease once every 5 years	$0.5 million
Higher overall yields	5% yield increase on all mustard seed	$2 million

For the most part, the above improvements would be introduced through new seed varieties. At the present time, seed costs are approximately $8 per hectare which is only 3% of the total value of the crop. Improvements which increase farm value by 10% will add approximately $20 per hectare of revenue to producers. Previous research has shown that many farmers are willing to operate on a two to one benefit to cost ratio for new seed varieties. This means that seed producers could increase prices by $15 per hectare on new varieties capable of increasing grower returns by 10%. Over all the land area devoted to mustard seed, this would amount to approximately $2 million per year. Of course, this is a gross revenue estimate: the net return after deducting all incremental costs, and working with fewer than 100% of all acres, would be considerably lower.

Conclusions

Based on the previous discussion, there appears to be several conclusions which can be drawn with respect to the potential for biotechnology research on mustard seed.

1. Even though Canada is the dominant producer of mustard seed for export purposes in the world, the economic value of the crop to Canadian farmers is quite low. With an average farm value of $38 million, the crop is similar to cabbage in economic returns.

2. There are a number of problems with mustard seed that could be tackled using biotechnology. Some of the more significant of these problems are disease resistance, yield improvements, drought tolerance, triazine resistance, and varying the oil composition of the finished product. The gross value of improvements in these areas at the farm level is in the vicinity of $5 to $6 million (Exhibit 4). A smaller level of domestic economic return could be anticipated for seed producers. In addition, the economic return to seed producers could be increased by exporting seed to other countries. This, however, would be limited by the small world production of the crop. Unless seed improvement come in the form of hybrid seed, the value to the seed industry would be seriously limited because farmers could simply save seed from year to year instead of purchasing new seed every year.

3. At the present time, there are no seed companies involved in developing and marketing proprietary mustard seed varieties. All seed used in the industry is of public origin, most of which is simply "bin run" seed. As a consequence, any biotechnology research and development in the short run would have to be carried out by government agencies. Some of this type of work is currently underway at the Agricultural Canada Research Station in Saskatoon.

4. Most respondents to our survey indicated that improving farmers' management capabilities in producing mustard seed was at least as important as research on the crop itself.

Recommendations

Although there are areas of needed improvement in mustard seed varieties, the economic value of the crop is very low. Although some spin off research from the major effort currently underway in Canola could be applied to mustard seed, the importance of the crop to Canadian agriculture cannot justify a major biotechnology research effort.

Soybeans

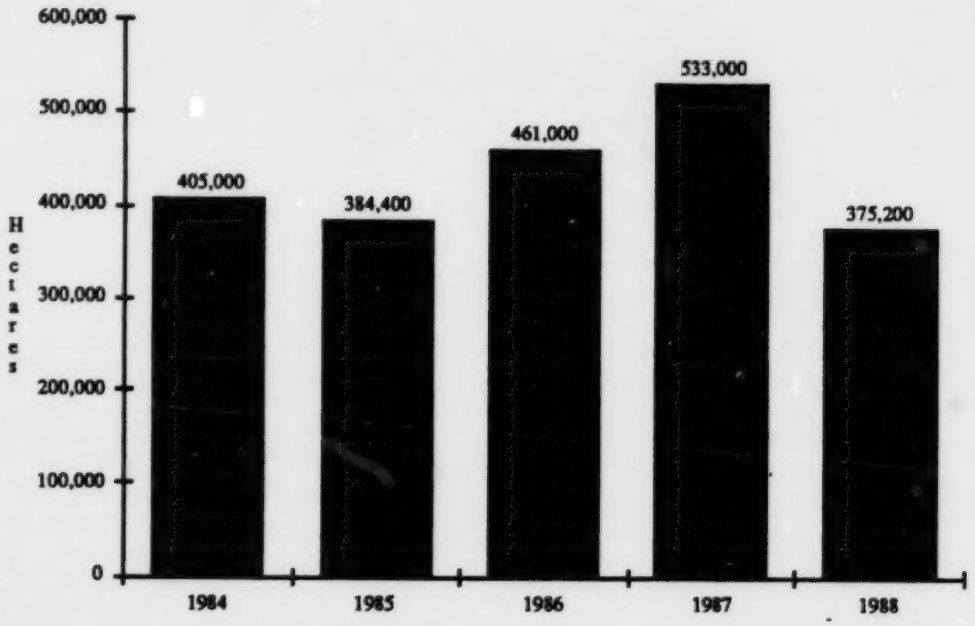
The third special crop to be analyzed in this report is soybeans. The specific assignment with respect to this crop is to analyze the economic benefits of developing soybeans with improved cold tolerance, disease resistance, and overall yield.

Canadian Production

Soybeans are a relatively new crop in Canada. Since first appearing on Canadian farms in the 1940's, they have grown to the point where, in 1987, over 500,000 hectares were produced. This has since declined because of a sharp decrease in the farm price of soybeans, but is expected to remain in the 400,000 to 500,000 hectare range in the future (Exhibit 1).

Exhibit 1

Canadian Production of Soybeans



As shown in Exhibit 2, the total value of soybeans over the past five years has averaged $278 million, reaching a peak of over $300 million in 1987. Although yields have shown a steady increase since the crop was first produced in Canada, the data in Exhibit 2 shows reduced yields in 1987 and 1988. This is because of the serious drought conditions which existed in these years.

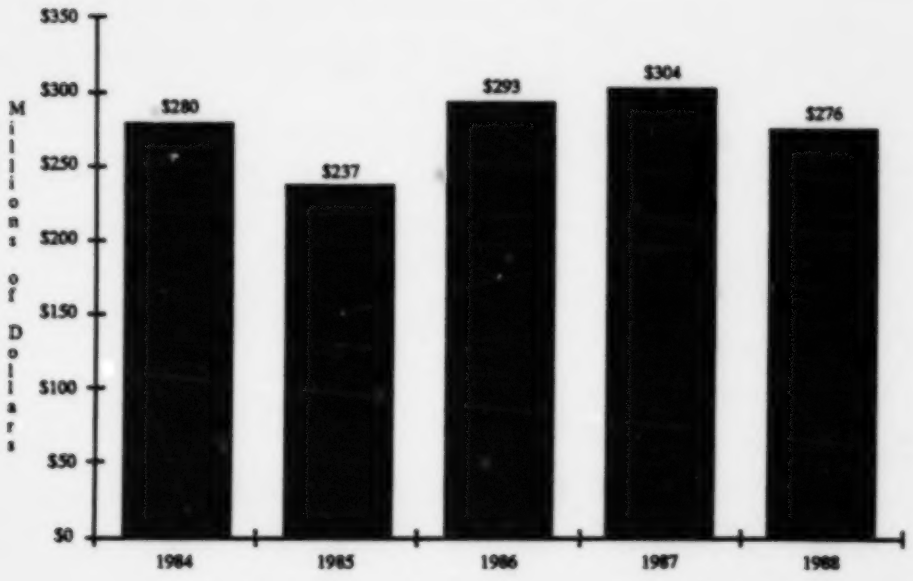
Exhibit 2

Soybean Production and Value Data

	Production (Tonnes)	Area (Hectares)	Yield (Tonnes/Ha)	Farm Price ($/Tonne)	Value ($)
1984	1,012,000	405,000	2.50	$277.00	$280,324,000
1985	960,000	384,400	2.50	$247.00	$237,120,000
1986	1,269,800	461,000	2.75	$231.00	$293,323,800
1987	1,152,600	533,000	2.16	$264.00	$304,286,400
1988	884,800	375,200	2.36	$313.00	$276,942,400
Average	1,055,840	431,720	2.45	$266.40	$278,399,320

Exhibit 3

Total Value of Soybeans Produced in Canada



The vast majority of soybeans in Canada are produced in Ontario. Quebec has a few thousand hectares, and very small amounts have been tried in Southern Manitoba. Relative to other field crops, soybeans are a fairly attractive option for farmers. Net profits per hectare for soybeans are estimated at $400 to $500 compared to net profits per hectare for corn of $300 to $400. Soybeans are particularly attractive as a rotational crop with corn because of the different timing of seeding and harvesting. This allows a farmer to spread his labour more evenly over the year.

Traditionally, soybeans have been grown only in the five southern counties of Ontario: Essex, Kent, Lambton, Middlesex, and Elgin. Although these counties still account for a high percentage of Ontario's soybean production, the crop is now grown in most arable areas of the province.

Uses of Soybeans

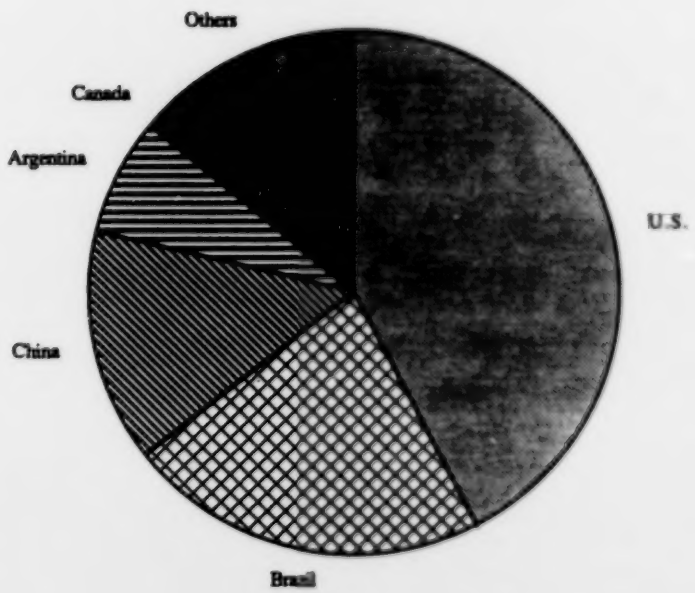
After harvest, soybeans can be either crushed into oil and meal components, or used as whole beans for on-farm feeding. Soybean oil is used for edible products such as margarine, salad dressing, and shortening, or for non-edible products such as paints, pesticides, and plastics. Soybean meal is used primarily as a source of protein in animal feeds. Whole soybeans can be used in a variety of products, but usually are roasted and used as animal feed on farms. The percentage of soybeans used in whole bean on-farm feeding has been increasing in recent years.

World Soybean Production and Trade

Total world production of soybeans in 1988 amounted to over 55,000,000 hectares. Of this total, the United States produced over 40%, Brazil over 20%, and China nearly 15%. The remaining 25% was produced in many other countries of the world. Canadian production amounts to less than 1% of total world production and just 2% of U.S. production.

Exhibit 4

World Production of Soybeans



Over the years, Canada has gone from a net importer of soybeans to a net exporter of the product. In 1988, exports totalled 200,000 tonnes while imported amounted to just 70,000 tonnes. The reasons for the shift from net importer to net exporter are: increased Canadian production (both yield and area) and the growing percentage of oilseed requirements in Canada being satisfied by Canola.

Virtually all imports of soybeans in 1988 came from the United States. Exports of soybeans (in order of importance) were made to: Japan, Singapore, Hong Kong, USSR, and Spain.

Seed Industry

Although there are several seed companies in Canada that have developed, and are marketing proprietary varieties of soybean seed, most of the seed used on an annual basis is "bin run" seed. This is because there are no hybrid varieties of soybeans currently on the market so there is no need for farmers to repurchase seed of a certain variety once they have purchased it initially. Estimates indicate that 70% to 75% of all soybean seed planted in any year is saved from previous years. As a result, of the 40,000 tonnes of soybean seed planted each year, only about 10,000 tonnes is supplied through seed organizations. At a value of approximately $500/tonne, the size of the soybean seed market in Canada can be estimated at $5,000,000.

Canadian seed companies are currently selling some soybean seed to the EEC. They feel there is some potential in this export market because of climatic similarities between the two regions. They also point out, however, that soybean production in the EEC is declining and that it is extremely difficult to get new seed varieties through the very rigid European seed licensing system. As a result, they see this opportunity as interesting, but not substantial.

Problems in the Production and Marketing of Soybeans

Respondents to our survey identified several problems associated with the production and marketing of soybeans. The key problems are discussed below:

1. There are some problems associated with the oil composition of soybeans. Soybean oil consists of three major elements: oleic acid, linoleic acid, and linolenic acid. Currently, soybean oil consists of only 8% to 9% linolenic acid. Because of this relatively low level of linolenic acid, soybean oil has a relatively short shelf life unless it is hydrogenated. Increasing the linolenic acid content of soybean oil could eliminate the need for this process. This would be desirable because hydrogenation poses risks of heavy metal contamination in the final product as well as the production of byproducts which are potential carcinogens. Increased shelf life could also be achieved through lowering the content of linoleic acid in soybean oil. In terms of being able to alter the oil composition of soybeans, several industry people mentioned the fact that this is much easier to do with canola than soybeans. Canola is referred to as a "designer oil" because it is relatively easy to develop varieties with different types of oil for different uses such as salad oil and deep frying oil. This task has proven to be much more difficult with soybeans.

2. Although the protein content of soybeans is quite high relative to many other crops, it could be higher. If the protein content could be increased to 50% or more from its present level of approximately 48%, direct on-farm feeding of ground soybeans would become more feasible. At the present time, industry experts estimate that approximately 15% of all soybeans grown in Canada are fed directly to livestock.

3. Although cold tolerance has been a problem with soybeans in the past, the industry experts interviewed in this study indicated that it is not a problem at the present time. Current varieties grow very well in almost all areas of Ontario, Quebec, the Maritimes, and southern Manitoba. In addition, new varieties from Siberia are available that have "massive levels of cold tolerance." These varieties are out-performing virtually all other varieties in quarantined trials across Canada. These could be available for Canadian farmers to use in the near future.

4. The limiting factor to expanded soybean production in Canada is not cold tolerance as much as it is the length of the frost free period and the drought conditions that exist in many areas of the country. For these reasons, all of the industry experts interviewed

thought it would be very unlikely that soybeans would ever be a major crop in Western Canada.

5. Although soybeans can suffer from root rot problems, this is not a serious problem in Canada at the present time. Varieties are available which have root rot resistance. In addition, low levels of the fungus can be controlled through proper management practices by farmers.

6. A potential problem in soybeans in Canada is Systematoda, an insect pest which is very extensive in parts of the United States. New varieties are available which will provide resistance to this insect. Seed company soybean breeders did not feel this was a serious problem.

7. All respondents to the survey mentioned increased yield as a desirable improvement in soybeans. Over the past several years, soybean yields have been increasing at a rate of about 30 kg/ha.

Economic Impact of Improvements

Wherever possible, industry experts were asked to estimate the economic impacts of solving some of the problems they identified. In some cases this was fairly straightforward, while in other cases this proved to be a difficult task.

1. With respect to altering the oil content of soybeans, most experts viewed this as a defensive strategy against canola. There appears to be a growing attitude that canola is a superior crop to soybeans for oil production, particularly in terms of the ease with which the oil composition of canola can be varied. The value of improvements in the ability to alter the oil composition of soybeans is to prevent canola from capturing a sizeable share of the soybean market.

2. While efforts to increase the protein content of soybeans might be useful for promoting more on-farm feeding, most researchers believe this can only be done at the expense of reducing the oil content of the product. Since soybean oil is more valuable than soybean meal, this is not seen as a good option at the present time.

3. Yield increases of 30 kg/ha at the five year average price of $266/tonne and the five year average area of 430,000 hectares translates into an economic value of approximately $3.3 million per year.

Conclusions

Based on the previous discussion, there appears to be several conclusions which can be drawn with respect to the potential for biotechnology research for soybeans.

1. A key objective of this part of the project was to look at the possible role of biotechnology related to developing improved cold tolerance is soybeans. Although this has been a problem in the past, apparently it is not a serious problem at the present time.

2. The major problem identified in the survey of industry experts relates to oil composition. This problem is being addressed by many researchers in major soybean producing countries. Canada probably does not have a competitive advantage in this area. Moreover, it probably is not in Canada's best long run interest to improve the oil composition of a crop which is a major competitor to Canola, a truly Canadian crop which increasingly is being seen as a superior oilseed. At the present time, there is nearly 4 million hectares of Canola grown in Canada. Millions of dollars of research funding have been allocated to Canola over the last several years to improve its oil quality and agronomic characteristics. These research expenditures are just now starting to pay off with the development of new hybrid Canola varieties that can be grown in both Canada and the United States. There is no doubt that the productivity of new Canadian research dollars would be higher in Canola than in soybeans.

3. Relative to many other crops, there does not appear to be a large number of significant problems associated with soybean production in Canada. Most of the important disease and insect problems are being controlled through resistant varieties.

4. Soybeans appear to be a difficult crop for applying biotechnology techniques.

5. The soybean seed industry in Canada is small and not well-developed at this time. There does not appear to be substantial foreign opportunities for Canadian soybean seed.

Recommendations

Based on this assessment of the potential for biotechnology research in soybeans, our conclusion is that this would be a very low priority area.

Winter Wheat

The final special crop to be analyzed in this report is winter wheat. The specific assignment is to determine the economic benefits of developing winter wheat varieties with improved winter hardiness, yield, and disease resistance for use on the Prairies.

Canadian Production

Winter wheat is a significant crop in Canada. The major type produced is hard red winter wheat for flour production. Over the past five years, the land area devoted to the crop has averaged in excess of 600,000 hectares. Winter wheat yields are fairly high, resulting in an average annual total farm value of nearly $200 million (Exhibit 1).

Exhibit 1

Winter Wheat Production and Value Data

	Production (Tonnes)	Area (Hectares)	Yield (Tonnes/Ha)	Farm Price ($/Tonne)	Value ($)
1984	1,291,300	483,200	2.67	$165.91	$214,269,600
1985	1,772,900	742,500	2.39	$160.99	$285,419,200
1986	1,981,400	804,200	2.46	$122.00	$241,730,800
1987	1,257,200	548,100	2.29	$93.30	$117,296,700
1988	1,345,700	527,100	2.55	$103.80	$139,683,600
Average	1,529,700	621,020	2.47	$129.20	$199,679,980

Exhibit 2 shows the trend in Canadian production of winter wheat. As can be seen, annual production is within a range of approximately 500,000 hectares to 800,000 hectares. Total value of winter wheat in Canada has been declining as production and prices have fallen. Exhibit 3 shows that total value reached a peak of over $285 million in 1985, and has fallen since that time to $140 million in 1988.

Exhibit 2

Canadian Production of Winter Wheat

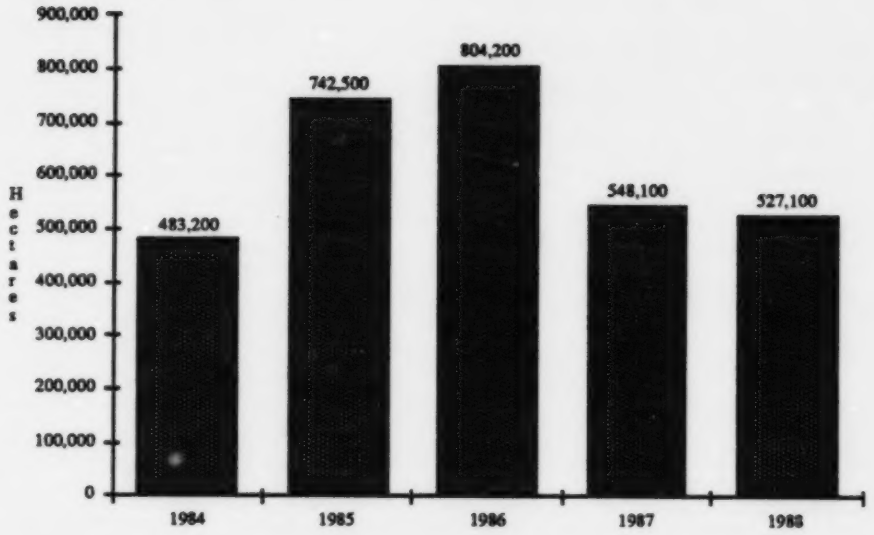
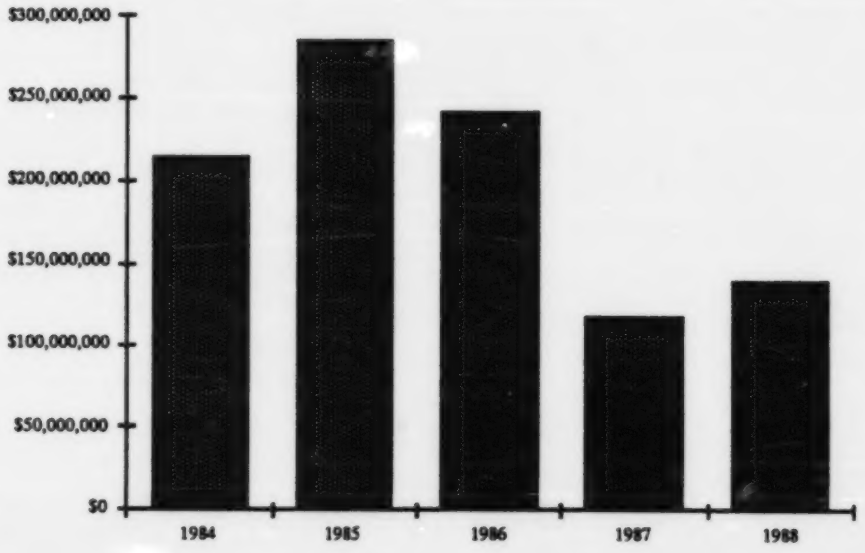


Exhibit 3

Total Value of Winter Wheat Production in Canada



Winter wheat has always been an important crop in Ontario. As illustrated in Exhibit 4, production in Ontario has averaged about 200,000 hectares over the past five years. This has not been the case in Western Canada. Although there has always been a substantial amount produced in Alberta, production in Manitoba and Saskatchewan developed in the late 1970's, and reached a peak of 530,000 hectares in the mid 1980's. Since 1986, production in Western Canada has declined by over 50%. As can be seen in Exhibit 5, the decline has occurred mainly in Saskatchewan and Manitoba. This decline is largely due to the fact that 1986 was a particularly bad year for winter kill. As a result, many farmers who decided to try the product in that year had a bad experience and did not grow it again the following year.

Exhibit 4

Production of Winter Wheat in Eastern and Western Canada

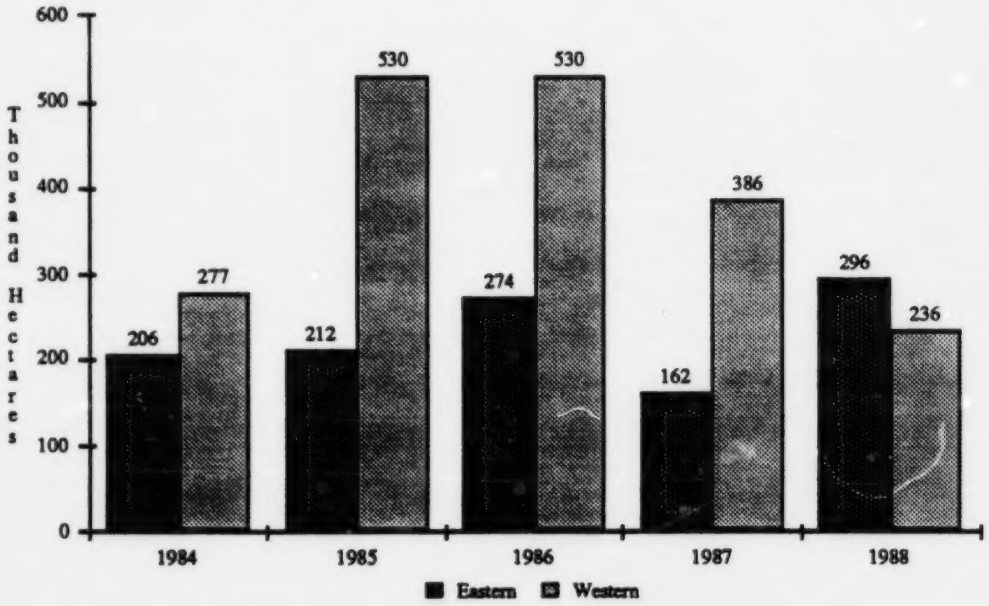
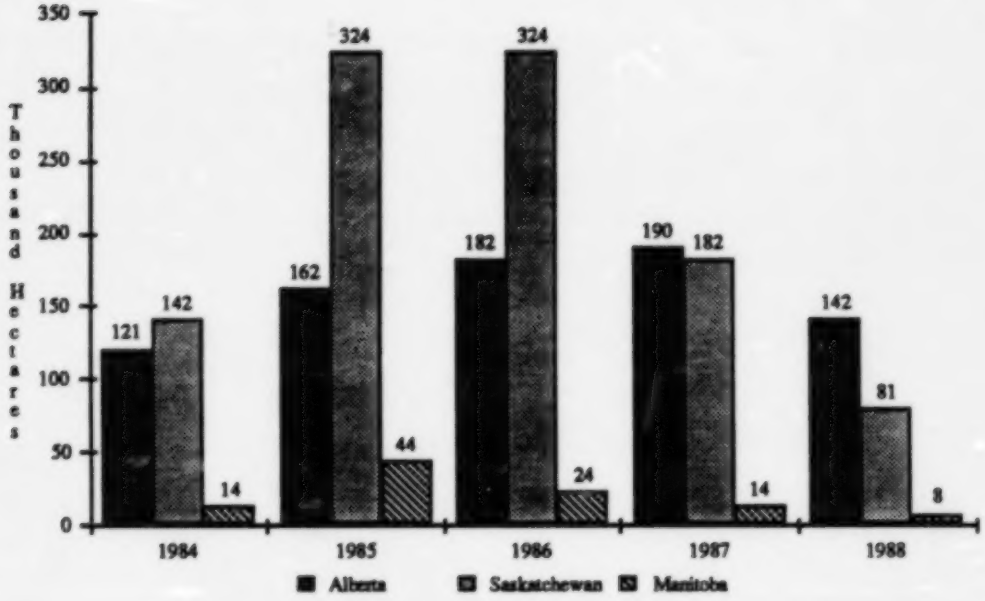


Exhibit 5

Production of Winter Wheat in Western Canada



Despite the fact that winter wheat is a sizeable crop in Canada, it is very small in comparison with spring wheat. In 1988, for example, total Canadian production of winter wheat was approximately 500,000 hectares, compared with over 10,000,000 hectares of spring wheat. Thus winter wheat in Canada accounts for only 5% of total production.

The production of winter wheat in Canada has been constrained by climatic factors. In the United States, where the climate is more favourable to the production of winter wheat, most of the wheat crop consists of winter varieties. In 1988, winter wheat in the United States totalled over 16,000,000 hectares.

Advantages and Disadvantages of Winter Wheat

Winter wheat has a number of advantages and disadvantages in relation to spring wheat. This section will outline these starting with the disadvantages.

1. The key problem with winter wheat production in Western Canada is that the proper climatic conditions are not always present in a wide geographical area. With the exception of Southern Alberta, most areas of the Prairies are subject to severe winter conditions which can cause excessive winter kill in winter crops. As a consequence, winter wheat is viewed as a very risky crop to produce in most regions of Western Canada.

2. Winter wheat varieties are more susceptible to rust than spring varieties.

3. The protein content of winter wheat varieties is not as high as most spring wheat varieties. This is reflected in a lower price for winter wheat compared to spring wheat. Available data over the past five years indicates that the price of winter wheat is approximately 10% below the comparable price of spring wheat.

4. The production of winter wheat requires better management on the part of growers, particularly as it relates to the timing of planting and harvest, and integration into a proper rotation

On the positive side, winter wheat offers many advantages to Western Canadian farmers. The key advantages are listed below:

1. Winter varieties have a theoretical yield advantage over spring varieties. Industry experts estimate that winter varieties can produce yields at least 25% higher than spring varieties. This is due to two factors: winter varieties have a longer growing period, and they can take better advantage of limited Prairie moisture in key growth periods. Despite the theoretical yield advantage, available data indicates that winter wheat does not yield as well as spring wheat in Western Canada. This is undoubtedly due to excessive winter kill.

2. Because winter wheat varieties are ready for harvest in August, they are not subject to the risk of frost as are most spring varieties. In the case of spring varieties, as one industry expert said, it is always "touch and go" in terms of whether they will reach maturity in time.

3. Winter wheat provides protection against water and wind erosion in the Fall and Winter months when the soil is exposed.

4. Winter wheat spreads the workload for farmers. Because it can be harvested in August, a farmer who grows both winter and spring varieties can extend the harvest season over two months compared to one month at the present time. This improves farmers' efficiency because they can farm more land with the same equipment and labour resources.

5. The best approach for winter wheat production is to plant the crop in the stubble of a prior crop. This is because the stubble helps to trap snow which is essential to provide insulation to prevent winter kill. The advantages of this are lower tillage costs and greater moisture retention.

6. Winter wheat production results in a reduced need for the use of herbicides because the crop is already established in the spring and can successfully compete against the weeds emerging at that time.

7. When all of the above factors are taken into account, the estimated gross returns from winter wheat are substantially higher than for spring wheat. A comparison of the economics of the two crops is shown in Exhibit 6 which shows the net returns per hectare for winter wheat to be $69 compared with $15 for spring wheat.

Exhibit 6

Comparison of the Costs and Returns for Winter and Spring Wheat

	Winter Wheat	Spring Wheat
Expenses ($/ha)		
Seeding Costs	$45.48	$43.89
Tillage Costs	$0.00	$25.33
Herbicide	$9.20	$21.86
Fertilizer	$83.26	$60.18
Other Costs	$22.48	$22.48
Total Costs	$160.43	$173.36
Yield (tonnes/ha)	1.99	1.39
Price ($/tonne)	$115.00	$136.00
Gross Returns ($/ha)	$229.43	$188.77
Net Returns ($/ha)	$69.00	$15.01

Source: Guy Lafonde, Cereals Agronomist, Agriculture Canada, Indian Head, Saskatchewan. Based on experimental data.

Seed Industry

Virtually all winter wheat produced in Canada is grown from public varieties. There is some interest at the present time among organizations such as the Pools in developing proprietary varieties, but this has not developed to any appreciable degree. As a result, virtually all certified seed is produced by seed growers and sold to other farmers on a direct basis or through some middleman such as farm supply dealers. Because there are no hybrid varieties on the market at the present time, much of the seed planted each year is "bin run" seed saved from the previous crop. Estimates place the amount of certified seed sold in any year at approximately 15% of the total amount of seed used. Given a seeding rate of 150 kg/ha and a certified seed cost of $0.30/kg., this translates into a total volume of certified seed sold of approximately $1.5 million in 1988.

There is an active winter wheat research program underway at the University of Saskatchewan. In addition, the Saskatchewan Wheat Pool is actively involved in developing improved varieties of winter wheat for use across the Prairies.

Problems in the Production and Marketing of Winter Wheat in the Prairies

Respondents to our survey cited several problems associated with the production of winter wheat in Western Canada. The major problems are noted below:

1. The key problem associated with winter wheat production in Western Canada is hardiness. This, of course, is related to the harsh climate in most areas of Western Canada. Lack of winter hardiness leads to winter kill which, if serious enough, will require the grower to till the soil and replant in the spring. Even if the winter kill is not so serious as to wipe out the crop, there is usually enough damage to negate any yield advantage a winter variety might have. The goal of researchers is to improve the hardiness of winter wheat to the same level as currently present in fall rye.

2. Winter varieties seem to be more susceptible to rust than spring varieties.

3. The protein content in winter wheat is not as high as in spring wheat. This leads to a price penalty of approximately 10% for winter wheat.

Economic Impact of Solving Current Problems

As noted earlier, the key problem associated with winter wheat production is lack of winter hardiness. If this problem could be overcome, the survey respondents estimated that the land area of winter wheat in Western Canada could expand to a minimum of 2,000,000 hectares from the current level of slightly more than 200,000 hectares. The major constraints to additional expansion are related to snowfall patterns and rotational considerations.

If the land area of winter wheat were to expand, this probably would occur at the expense of spring wheat. As a result, the economic benefit to expansion would be the differential net returns of winter wheat over spring wheat. This has been estimated to be $54 per hectare ($69 - $15). As a result, net benefits to Prairie farmers would be $97,200,000 per year ($54 times the additional land area of 1.8 million hectares).

Seed producers would also benefit from improved winter varieties. Assuming improved varieties of winter wheat can generate gross returns $40 higher than spring wheat (Exhibit 6), and that these are shared on a 2 to 1 basis with farmers (other studies in a similar area have shown the 2:1 benefit to cost ratio to be appropriate), then seed costs could increase by approximately $13/ha. Over 1.8 million hectares, at a 15% certified seed usage rate, this would amount to a benefit of $3.5 million.

The agricultural chemical industry most likely would experience a negative impact. Industry experts estimate that chemical costs on winter wheat could be as much as $10/ha lower than on spring wheat. On 1.8 million hectares this would amount to a sales loss of nearly $20 million. Assuming a gross margin on chemicals of 50%, the contribution loss to the chemical industry would be somewhere in the vicinity of $10 million.

In addition to the above quantitative impacts, some qualitative issues can also be raised. Foremost among these is the conservation benefits of winter wheat. By providing a cover crop in the fall and winter, water and wind erosion could be reduced significantly. It is virtually impossible to put a quantitative value on this benefit.

Conclusions

Based on the previous discussion, there appears to be a few major conclusions which can be drawn with respect to the potential for biotechnology research on winter wheat.

1. The production of winter wheat in the Prairies has a lot of potential. Although currently there is less than 250,000 hectares of winter wheat in Western Canada, there is a potential for 2,000,000 hectares.

2. The key limiting factor to the growth of winter wheat in Western Canada is winter hardiness. There are additional problems with respect to diseases and protein content, but these are minor in comparison with hardiness.

3. Winter wheat offers a large number of advantages to growers over spring wheat. When considered together, these advantages can contribute $55 per hectare in incremental net returns to growers. In total, the value of these improvements approaches $100,000,000 annually.

4. The seed industry can also benefit form improvements in winter wheat. The annual benefit to the seed industry is in the neighborhood of $3 million.

Recommendations

The value of improvements in winter wheat appear to be of sufficient size to justify devoting additional research resources to this area

Winter Wheat Research in Canada

The final part of this project is to evaluate current winter wheat research programs in Canada, and make recommendations concerning the expansion of biotechnology research in this area. At the present time, there are four groups conducting research on winter wheat in Western Canada. These groups are:

Crop Development Centre, University of Saskatchewan

Plant Science Department, University of Manitoba

Agriculture Canada, Lethbridge, Alberta

Saskatchewan Wheat Pool

The remainder of this section discusses each of these programs in some depth. This discussion will focus on describing the current research emphasis of each group, some of their perceived limitations, the degree to which they collaborate with industry, and the potential role of biotechnology in the various programs.

University of Saskatchewan

The largest program is that headed by Dr. Brian Fowler at the Crop Development Centre of the University of Saskatchewan. Dr. Fowler's program consists of a lab, several graduate students, and a field testing program. This program is very comprehensive, covering the following areas:

- This group has done much of the agronomic research that has been done on winter wheat in Western Canada. This consists of research in such areas as fertilization, weed control, and tillage. They have just completed a five year project in this area and are in the process of completing the data analysis and writing up the results.

- They also have done a considerable amount of work in the area of equipment. In particular, they have done a number of studies dealing with the use of different equipment for no-till seeding of winter wheat.

- The group has worked in the pathology area in the past, but has recently scaled back this effort. Much of their pathology work now is being done by Agriculture Canada at Lethbridge.

- The major effort of the winter wheat group at the Crop Development Centre is in plant breeding with particular emphasis on the genetics of winter hardiness. In this area they are pursuing a cooperative venture with the University of Colorado in which they are attempting to develop an interspecific crop by combining winter wheat with a Russian grass called Agropyron. Agropyron is well-known for its hardiness. The purpose of this program, of course, is to transfer this characteristic to winter wheat.

In an interview with Dr. Fowler, he mentioned several limitations his group had with respect to developing improved hardiness in winter wheat. The first area mentioned was field testing. Although the acreage of winter wheat in Western Canada has expanded considerably over the past ten years, the resources devoted to testing have remained more or less constant. There is an obvious need to improve this situation.

Another limitation deals with funding. Much of the funding supporting winter wheat research is so-called "soft money" which, of course, is subject to being reduced at any time. This makes it very difficult to plan any type of long term research effort which is necessary for a successful breeding program.

Another key limitation is the lack of biotechnology support. In the past there has been some interaction with the Plant Biotechnology Institute in Saskatoon, but this has not worked all that well. The main problem with this relationship was the fact that the people in the Plant Biotechnology Institute were interested in fast results and, therefore, devoted most of their time to Canola and had very little time to spend on winter wheat. Dr Fowler points out that there is very little known at the present time about the genes that regulate winter hardiness. As a result, his approach at the moment centers around transferring whole chromosomes. This, of course, is not the most efficient way to tackle the problem.

Dr. Fowler's opinion is that additional funding in biotechnology would be very useful in helping achieve the goal of developing improved hardiness in winter wheat. There are two major areas in which biotechnology could play a role: locating hardiness genes and expanding interspecific genetics.

In terms of industry collaboration, Dr. Fowler's group works very closely with organizations like the Saskatchewan Wheat Pool. This is evidenced by the fact that the main winter wheat researcher at the Saskatchewan Wheat Pool worked with Dr. Fowler as a graduate student while on a paid leave of absence. In addition, a number of studies in the area of equipment are conducted in cooperation with industry groups.

In summary, the work being done by Dr. Fowler represents the major research effort on winter wheat in Western Canada. Dr. Fowler has an extremely comprehensive program ranging from agronomics to genetics. He has developed close relations with the industry as well as other researchers. His program could benefit a great deal from additional biotechnology support.

University of Manitoba

A second, and considerably smaller program, is under the direction of Dr. Anita Brule-Babel at the University of Manitoba. A former graduate student of Dr. Fowler, Dr. Brule-Babel's program concentrates on the eastern prairies and has projects in improved hardiness, improved quality, stem rust, shorter straw, and anther culture.

In an interview with Dr. Brule-Babel, she listed several limitations to her efforts in winter wheat research. The key limitation she cited was the fact that winter wheat researchers do not have a well-developed set of basic tools to use. This is evidenced, she said, by the fact that approaches like anther culture have not been made to work well in wheat. As a result, the success rate of this approach is quite low. This means that continued use of the technique requires substantial resources. Research aimed at improving basic tools such as anther culture could prove quite useful in the future.

Dr. Brule-Babel has not developed a close relationship with industry. Quite to the contrary, she indicated that it was difficult to work with industry because they were often not willing to share information.

In summary, it appears that the program at the University of Manitoba is not nearly as comprehensive or well-developed as that at the University of Saskatchewan.

Agriculture Canada, Lethbridge, Alberta

The third active winter wheat program in Western Canada is that of Agriculture Canada at Lethbridge, Alberta. This program is managed by Dr. Julian Thomas.

The Agriculture Canada program is almost exclusively a breeding program focusing on diseases, pests, shorter straw, and increased yields. The station does have a molecular biologist who spends some time on winter wheat. The major approach used by the research group is haploidy to produce inbred lines which can then be used in conventional breeding. The group does not use anther culture because they feel it is too labour intensive.

In an interview, Dr. Thomas expressed a firmly held belief that conventional plant breeding is the best approach to use in developing improved hardiness in winter wheat. He does not see a major role for biotechnology in this area.

Saskatchewan Wheat Pool

The three Prairie Pools have linked efforts in crop research in order to avoid duplication and increase overall effectiveness. In this regard, the Saskatchewan Wheat Pool has been given responsibility for wheat. The key person involved with winter wheat is Gordon Hultgeen, an agronomist with that organization. Mr. Hultgreen is a former graduate student of Dr. Fowler at the University of Saskatchewan. Although the Saskatchewan Wheat Pool is not actively involved in breeding winter wheat; they are monitoring new lines and concentrating their efforts on developing improved agronomic techniques for growing the crop. As a result, there is a fair amount of complementarity between the Saskatchewan Wheat Pool and the University of Saskatchewan. It is interesting to note that the Pools are in a position to be the major marketers of new winter wheat seed. This fact makes the linkage with the University of Saskatchewan quite important with respect to an overall strategy for developing and marketing improved winter wheat varieties in the Prairies.

POSSIBILITÉS DE RECHERCHE EN BIOTECHNOLOGIE POUR LES CULTURES SPÉCIALES AU CANADA

Préparé

par

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Sommaire

En janvier 1990, nous avons entrepris un projet d'étude du potentiel biotechnologique canadien dans le domaine des grandes cultures spéciales. Nous avons identifié quatre types de cultures qui on fait l'objet d'une évaluation détaillée : les brassicas végétales, les graines de moutarde, les graines de soja et le blé d'hiver. Les objectifs du projet étaient les suivants :

1. Recueillir des données sur les surfaces cultivées, la production et la valeur, par région, pour les cinq dernières années, pour chacune des quatre cultures.

2. Déterminer les utilisations actuelles de chaque culture.

3. Déterminer les possibilités et problèmes principaux, en ce qui concerne la production, la commercialisation et l'utilisation de chaque culture.

4. Déterminer la valeur des améliorations pour chaque culture.

5. Déterminer le savoir-faire canadien disponible, en ce qui concerne la mise au point et la commercialisation de produits possédant des caractéristiques améliorées.

Le projet comportait deux étapes. La première étape portait sur les objectifs un à quatre inclusivement, pour chacun des quatre types de culture. Après avoir examiné ces résultats avec le client, nous avons décidé de réaliser l'objectif cinq seulement en ce qui concerne le blé d'hiver, ayant jugé que les avantages économiques de la biotechnologie dans les trois autres domaines n'étaient pas assez importants pour justifier une étude plus poussée.

Les données utilisées dans le cadre de cette recherche provenaient de deux sources principales. La première : les renseignements statistiques fournis par Statistique Canada, les ministères provinciaux de l'Agriculture, la Commission canadienne du blé et le ministère de l'Agriculture des États-Unis. La seconde : une série d'interviews approfondies avec divers représentants de l'industrie, du gouvernement et des universités à travers le Canada, et quelques autres aux États-Unis.

Les conclusions et résultats principaux de l'étude sont présentés ci-dessous, par type de grande culture.

Brassicas végétales

1. Sauf en ce qui concerne les rutabagas, le Canada ne dispose pas d'un avantage concurrentiel dans la production des brassicas végétales. Par conséquent, la production de ces cultures au Canada est extrêmement faible.

2. Bien que le Canada dispose d'un avantage concurrentiel dans la production des rutabagas, la demande de ce produit décline tant au Canada que dans les marchés d'exportation.

3. Au Canada, il n'existe pas d'industrie des semences de brassica végétale susceptible de bénéficier de projets de recherche en biotechnologie.

4. Au Canada, la sélection conventionnelle des brassicas végétales n'existe pas; pourtant celle-ci serait nécessaire pour l'application des progrès de la biotechnologie à des variétés réelles.

5. Dans le cadre de l'enquête, tous les répondants ont indiqué que la sélection conventionnelle est actuellement l'activité de recherche la plus importante. Aucun répondant n'estime que des dépenses de recherche en biotechnologie dans ce domaine seraient justifées au Canada.

6. Il semble qu'au Canada, dans un avenir proche, les possibilités de recherche en biotechnologie soient restreintes, en ce qui concerne les brassicas végétales.

Graines de moutarde

1. Même si le Canada est le principal producteur mondial de graines de moutarde destinées à l'exportation, pour les agriculteurs canadiens, la valeur économique de cette culture reste assez faible.

2. En ce qui concerne les graines de moutarde, la biotechnologie pourrait permettre de résoudre plusieurs problèmes. Parmi ceux-ci, les plus importants sont : l'amélioration du rendement, la résistance aux maladies, à la sécheresse et à la triazine, et la variation de la composition de l'huile dans le produit fini. Dans ces domaines, la valeur brute des améliorations, au niveau de l'exploitation agricole se situe entre 5 et 6 millions de dollars. On peut s'attendre à ce que les producteurs de graines obtiennent un niveau moins élevé de rendement économique sur le marché intérieur. D'autre part, les producteurs de graines pourraient améliorer le rendement économique en exportant des graines dans d'autres pays. Toutefois, cela serait limité par la faible niveau de la production mondiale de graines de moutarde. A moins que les améliorations ne soient axées sur la production de graines hybrides, la valeur de cette culture pour les producteurs de graines serait considérablement limitée, puisque les agriculteurs pourraient simplement garder les graines d'une année à l'autre, au lieu de les acheter chaque année.

3. Actuellement, il n'existe pas de producteurs de graines engagés dans la mise au point et la commercialisation de variétés de graines de moutarde en propriété exclusive. Toutes les graines utilisées dans ce secteur sont d'origine publique et la plupart sont simplement des graines "tout-venant". Par conséquent, à court terme, toute R-D en biotechnologie dans ce domaine devra être effectuée par des organismes gouvernementaux. Certains travaux de ce type sont actuellement en cours dans la Station de recherches d'Agriculture Canada à Saskatoon.

4. La plupart des répondants ont indiqué que l'amélioration des capacités de gestion des agriculteurs qui produisent des graines de moutarde est au moins aussi importante que la recherche sur la culture elle-même.

5. Bien qu'il soit nécessaire d'apporter certaines améliorations, en ce qui concerne les variétés de graines de moutarde, la valeur économique de cette culture reste très faible. Si les recherches considérables actuellement effectuées sur le Canola peuvent avoir des retombées sur la production de graines de moutarde, il n'en reste pas moins que l'importance de cette culture pour l'agriculture canadienne ne peut justifier un effort considérable de recherche biotechnologique.

Graines de soja

1. En ce qui concerne les graines de soja, un objectif clé visait à étudier le rôle éventuel de la biotechnologie axée sur l'amélioration de la résistance au froid. Si cela constituait un problème dans le passé, il semble que ce ne soit plus cas actuellement.

2. Le principal problème identifié lors de l'enquête menée auprès d'experts de l'industrie se rapporte à la composition de l'huile. Ce problème est étudié par beaucoup de chercheurs dans les principaux pays producteurs de soja. Le Canada ne dispose probablement pas d'avantage concurrentiel dans ce domaine. D'autre part, à long terme, il n'est probablement pas dans l'intérêt du Canada d'améliorer la composition de l'huile d'une culture qui concurrence fortement le Canola, un produit véritablement canadien que l'on considère de plus en plus comme un oléagineux supérieur. Actuellement, près de 4 millions d'hectares sont consacrés à la culture du Canola au Canada. Au cours des dernières années, on a affecté des millions de dollars à la recherche sur le Canola, en vue d'améliorer la qualité de l'huile et les caractéristiques agronomiques de ce produit. Ces dépenses de recherche commencent seulement à porter leur fruits, avec la mise au point de nouvelles variétés de Canola hybrides qui peuvent être cultivées au Canada et aux États-Unis. Il est certain que le rendement de nouveaux fonds de recherche canadiens serait plus élevé dans le secteur du Canola que dans celui des graines de soja.

3. Comparativement à beaucoup d'autres cultures, il ne semble pas que la production de graines de soja pose beaucoup de problèmes importants au Canada. La plupart des grands problèmes que posent les maladies et les insectes sont en train d'être contrôlés par l'utilisation de variétés résistantes.

4. Il semble qu'il soit difficile d'appliquer des procédés biotechnoliques à la culture des graines de soja.

5. Actuellement, le secteur de la production des graines de soja est petit et peu développé au Canada. Il ne semble pas qu'il existe des possibilités substantielles d'exportation de graines de soja canadiennes.

6. Compte tenu de cette évaluation du potentiel de la recherche biotechnologique sur les graines de soja, nous concluons que ce domaine ne devrait recevoir qu'une très faible priorité.

Blé d'hiver

1. Le potentiel de production de blé d'hiver dans les Prairies est considérable. Bien que le blé d'hiver ne soit actuellement cultivé que dans moins de 250 000 hectares dans l'Ouest du Canada, cette surface pourrait être de 2 millions d'hectares à l'avenir.

2. La résistance est le principal facteur qui limite la croissance du blé d'hiver dans l'Ouest du Canada. D'autres problèmes existent -- les maladies et la teneur en protéines --, mais ils sont mineurs comparativement à celui de la résistance.

3. Comparativement au blé de mars, le blé d'hiver présente de nombreux avantages pour les cultivateurs. Ensemble, ces avantages peuvent permettre aux cultivateurs d'obtenir un rendement net supplémentaire allant jusqu'à 55 dollars par hectare. Aux prix actuels, la valeur totale de ces améliorations se rapproche des 100 millions de dollars par an. Cette valeur variera avec le prix du blé, mais elle restera substantielle et positive.

4. Les producteurs de graines peuvent aussi bénéficier des améliorations apportées au blé d'hiver. Pour ce secteur, la valeur de ces avantages se chiffre à environ 3 millions de dollars.

5. La valeur des améliorations apportées au blé d'hiver semble être suffisamment importante pour justifier l'affectation de ressources supplémentaires dans ce domaine.

6. Quatre programmes canadiens de recherche sur le blé d'hiver sont en cours dans l'Ouest du Canada. Le plus important et le plus développé est celui de l'Université de la Saskatchewan. Il semble justifiable d'accorder un grande priorité à l'affectation de fonds de recherche pour ce programme, en vue de la mise au point de cultures interspécifiques et du repérage de gènes régulateurs de la résistance au froid.

Recommandations

Compte tenu de l'analyse effectuée dans le cadre de ce projet, nous pouvons énoncer les recommandations suivantes. On devrait envisager sérieusement d'augmenter le soutien financier de la biotechnologie axée sur l'amélioration de la résistance du blé d'hiver. La majeure partie de ces fonds supplémentaires devrait être accordée au programme de mise au point du blé d'hiver en cours à l'Université de la Saskatchewan. On devrait envisager d'affecter une partie de ces fonds à la mise au point d'instruments de base tels que la culture d'anthères à l'Université du Manitoba.

Nous ne recommandons pas d'affecter des fonds supplémentaires à la recherche sur les brassicas végétales, les graines de soja ni les graines de moutarde.